

## CLAIMS

1. Apparatus for moving molten metal in a bath of molten metal, comprising:

a rotatable moving member suited to be disposed in a bath of heated molten metal to move the molten metal;

a shaft having an upper end suited to extend out of the molten metal, and a lower end suited for disposition into the molten metal, the shaft having a longitudinal shaft axis;

power means connected to the upper end of the shaft for rotating the shaft;

means for connecting the lower end of the shaft to the moving member for rotating the moving member in the molten metal;

an elongated tubular shield having a longitudinal shield axis, the tubular shield receiving the shaft therein such that the shaft axis coincides with the shield axis, the tubular shield having a length sufficient to substantially enclose that portion of the shaft disposed in the molten metal;

the tubular shield being formed of a material that is resistant to the heat of the molten metal;

means for longitudinally prestressing the tubular shield, comprising:

an upper clamping member mounted on an upper portion of the shaft and clampingly engaged with an upper portion of the shield;

a lower clamping member longitudinally spaced from the upper clamping member and mounted on a lower portion of the shaft and clampingly engaged with a lower portion of the shield;

means for adjusting the longitudinal distance between the upper clamping member and the lower clamping member to longitudinally clamp that portion of the shield therebetween;

whereby the shield is disposed such that the maximum longitudinal stress on the shield is in compression as it is rotated by the power means.

2. Apparatus as defined in claim 1, in which the shaft is hollow for passing a gas through the upper end of the shaft to a position adjacent the moving member.

3. Apparatus as defined in claim 1, including:  
the shaft having a longitudinal passage therethrough;  
a source of a scrubbing gas;  
means for introducing the scrubbing gas through the passage in the shaft into a bath of molten metal to remove hydrogen from the bath of molten aluminum.

4. Apparatus as defined in claim 1, in which the shield is formed of a ceramic.

5. Apparatus as defined in claim 1, in which the shield is formed from either a ceramic or a graphite.

6. Apparatus as defined in claim 1, in which the shield comprises at least one inner shield member and an outer shield member telescopically received in the inner

shield member, such that an inner surface of the outer shield member faces an outer surface of the inner shield member and is attached thereto.

9  
10 Apparatus as defined in claim 6, in which the moving member is attached to a lower portion of the outer shield member.

9  
11 Apparatus as defined in claim 6, in which the inner shield member is disposed within the outer shield member to form a shoulder adjacent the moving member, and including one of said clamping members being mounted on the shaft and engaging said shoulder to longitudinally compress the shield members.

13  
12 Apparatus as defined in claim 1, including an upper clamping nut mounted on the shaft and engaged with the shield, and a lower clamping nut mounted on the shaft and engaged with the shield, and means for moving one of the clamping nuts toward the other of the clamping nuts to longitudinally compress the shield between the clamping nuts.

12  
10 Apparatus as defined in claim 6, in which the inner shield member has an internal diameter greater than the outer diameter of the shaft to form a chamber therebetween.

14  
11 Apparatus as defined in claim 1, in which the moving member is an agitating

2 member.

1 <sup>15</sup>  
12. Apparatus as defined in claim 1, in which the moving member is a pumping  
2 member.

1 <sup>3</sup>  
13. Apparatus as defined in claim 2, in which the moving member is so joined to  
2 the lower end of the tubular shield as to form a gas chamber adjacent the lower end of the  
3 shaft for receiving gas from the upper end of the shaft; and  
4 including an orifice in the moving member for passing the gas into the  
5 molten metal in a downward direction generally parallel to the shaft axis.

1 <sup>4</sup>  
14. Apparatus as defined in claim 2, including an inner shield having a radial  
2 surface and telescopically mounted in the first mentioned shield and laminated thereto;  
3 a washer engaging the radial surface of the inner shield; and  
4 a clamping nut engaging the washer to apply a longitudinally  
5 compressive force on the inner shield.

1 <sup>5</sup>  
15. Apparatus as defined in claim <sup>4</sup>14, in which the outer shield has a lower radial  
2 surface adjacent the radial surface of the first mentioned shield, and the washer engages  
3 the radial surface of both the first mentioned shield and the inner shield to longitudinally  
4 compress both of said shields along their respective lengths.

1           16.   Apparatus as defined in claim 1, in which the shaft has a first coefficient of  
2 thermal expansion, and the shield has a second coefficient of thermal expansion such that  
3 the difference between the length of the shaft and the length of the tubular shield varies as  
4 a function of the temperature of the molten metal, and including a bias member mounted  
5 between the shaft and the tubular shield to accommodate the difference between the shaft  
6 and shield length.

1           17.   Apparatus as defined in claim 16, in which the upper clamping member  
2 comprises a first nut threadably mounted on the upper end of the shaft; a second nut  
3 threadably mounted in the lower end of the shaft, a belleville or other suitable spring  
4 mounted on the shaft and between at least one of said nuts and the tubular shield to apply  
5 a compressive bias on the shield that varies as the difference in the variation of the lengths  
6 of the shaft and the shield.

1           <sup>19</sup>  
~~18.~~   Apparatus for moving molten metal in a bath of molten metal, comprising:  
2                           a rotatable moving member suited to be disposed in a bath of heated  
3 molten metal;  
4                           a shaft having an upper end suited to extend out of the molten metal,  
5 and a lower end suited for disposition into the molten metal, the shaft having a longitudinal  
6 shaft axis;  
7                           power means connected to the upper end of the shaft for rotating the  
8 shaft;

means for connecting the lower end of the shaft to the moving member for rotating the moving member in the molten metal;

an elongated tubular shield having a longitudinal shield axis, the tubular shield receiving the shaft therein such that the shaft axis coincides with the shield axis, the tubular shield having a length sufficient to substantially enclose that portion of the shaft disposed in the molten metal;

the tubular shield being formed of a material that is resistant to the heat of the molten metal;

an upper fastener member mounted on the shaft;

a lower fastener member mounted on the shaft in a position longitudinally spaced from the upper fastener member;

the shaft and the tubular shield being formed of materials having different thermal expansion characteristics whereby the difference in the respective lengths of the shaft and the tubular shield varies as a function of their operating temperature; and

a bias member mounted between the tubular shield and the shaft such that the distance between one end of the shaft and the corresponding end of the shield remains relatively fixed, and the distance between opposite end of the shaft and the shield varies as the temperature.

<sup>20</sup>  
~~19.~~ Apparatus as defined in claim <sup>19</sup>~~18~~, in which the shaft is hollow for passing a gas through the upper end of the shaft to a position adjacent the moving member.

1 ~~20.~~<sup>21</sup> Apparatus as defined in claim ~~18~~<sup>19</sup>, including:

2 the shaft having a longitudinal passage therethrough;

3 a source of a scrubbing gas;

4 means for introducing the scrubbing gas through the passage in the  
5 shaft into a bath of molten metal to remove hydrogen from the bath of molten aluminum.

1 ~~21.~~<sup>22</sup> Apparatus as defined in claim ~~18~~<sup>19</sup>, in which the shield is formed of a ceramic.

1 ~~22.~~<sup>23</sup> Apparatus as defined in claim ~~18~~<sup>19</sup>, in which the shield is formed from either a  
2 ceramic or a graphite.

1 ~~23.~~<sup>24</sup> Apparatus as defined in claim ~~18~~<sup>19</sup>, in which the shield comprises at least one  
2 inner shield member, and an outer shield member telescopically received in the inner  
3 shield member, such that an inner surface of the outer shield member faces an outer  
4 surface of the inner shield member and is attached thereto.

1 ~~24.~~<sup>25</sup> Apparatus as defined in claim ~~23~~<sup>24</sup>, in which the moving member is attached  
2 to a lower portion of the outer shield member.

1 ~~25.~~<sup>26</sup> Apparatus as defined in claim ~~23~~<sup>24</sup>, in which the inner shield member is  
2 disposed within the outer shield member to form a shoulder adjacent the moving member,

and including one of said clamping members being mounted on the shaft and engaging said shoulder to longitudinally compress the shield members.

<sup>28</sup>  
26. Apparatus as defined in claim <sup>19</sup>~~18~~, including an upper clamping nut mounted on the shaft and engaged with the shield, and a lower clamping nut mounted on the shaft and engaged with the shield, and means for moving one of the clamping nuts toward the other of the clamping nuts to longitudinally compress the shield between the clamping nuts.

<sup>24</sup>  
27. Apparatus as defined in claim ~~23~~, in which the inner shield member has an internal diameter greater than the outer diameter of the shaft to form a chamber therebetween.

<sup>29</sup>  
28. Apparatus as defined in claim <sup>19</sup>~~18~~, in which the moving member is an agitating member.

<sup>30</sup>  
29. Apparatus as defined in claim <sup>19</sup>~~18~~, in which the moving member is a pumping member.

<sup>31</sup>  
30. Apparatus as defined in claim <sup>19</sup>~~18~~, in which the moving member is so joined to the lower end of the tubular shield as to form a gas chamber adjacent the lower end of the shield from the hollow shaft; and

including an orifice in the moving member for passing the gas into the molten metal in a downward direction generally parallel to the shaft axis.

32  
31. Apparatus as defined in claim 19, including an inner shield having a radial surface and telescopically mounted in the first mentioned shield and laminated thereto; a washer engaging the radial surface of the inner shield; and a clamping nut engaging the washer to apply a longitudinally compressive force on the inner shield.

33  
32. Apparatus as defined in claim 19, in which the outer shield has a lower radial surface adjacent the radial surface of the first mentioned shield, and the washer engages the radial surface of both the first mentioned shield and the inner shield to longitudinally compress both of said shields.

18  
33. Apparatus as defined in claim 1, in which the shaft has a first coefficient of thermal expansion, and the shield has a second coefficient of thermal expansion such that length of the shaft and the length of the tubular shield vary as a function of the temperature of the molten metal, and including a bias member mounted between the shaft and the tubular shield to accommodate differences between the shaft length and the shield length.

19  
34. Apparatus as defined in claim 18, in which the upper clamping member comprises a first nut threadably mounted on the upper end of the shaft; a second nut threadably mounted on the lower end of the shaft, a belleville or other suitable spring

4 mounted on the shaft between one of said nuts and the tubular shield to apply a  
5 compression bias on the shield that varies as the difference in the variation of the lengths  
6 of the shaft and the shield.